Tropical Brown- and Black-spored Mexican Agarics with Particular Reference to *Gymnopilus* 5

L. Guzmán-Dávalos

Departamento de Botánica y Zoología, Universidad de Guadalajara, Apdo postal 1-139, Zapopan, Jalisco 45110, Mexico

Introduction

There are relatively few published studies on tropical Mexican fungi, and dark-spored agarics appear to be a particularly neglected group. Mexican surveys have been directed mainly to the temperate forests and to light-spored genera, although modern mycology in Mexico started with the dark-spored, hallucinogenic mushrooms (Guzmán, 1990). Many mycologists preferred to collect in *Pinus–Quercus* forests where the conditions are more favourable than in the tropical regions. As Nishida (1989) pointed out, 'A mushroom collector there (warm tropical climates) must gather his fungi early in the morning, take his notes, and dry the specimens in a timely fashion'. Maintenance and transport of dry mushrooms in the tropics are also a problem; high atmospheric humidity reaching the specimens allows rapid growth of moulds.

To address the tropical dark-spored (brown and black) Mexican agarics, this chapter considers the mycodiversity of Mexico and the vegetation types present in the country with emphasis on the tropics. The history of Mexican studies of agarics and how they have contributed to the current state of knowledge is then briefly mentioned. Finally, the special features of *Gymnopilus* are described.

Mexican Biodiversity and Vegetation Types

Mexico has a privileged position in North America from a biodiversity point of view. Situated at the transition between the Neotropical and Nearctic realms,

© CAB *International* 2002. *Tropical Mycology*, Vol. 1, *Macromycetes* (eds R. Watling, J.C. Frankland, A.M. Ainsworth, S. Isaac and C.H. Robinson)

Mexico has representatives from both, as well as endemic species owing to the confluence of the two regions. For this reason, Mexico is considered a country of megadiversity (Mittermeier, 1988). It presents a mosaic of vegetation types, with temperate forests (i.e. *Quercus* and conifer forests) and alpine vegetation in the mountains; xerophytic vegetation and grasslands on the Mexican Plateau; tropical and subtropical vegetation on the coasts and in the south of the country and aquatic vegetation represented in some regions. The tropical and subtropical vegetation in Mexico is represented by tropical rainforests (or tropical evergreen forests), tropical subdeciduous and deciduous forests and the mesophytic or cloud forests (Rzedowski, 1978). The last have also been included in 'the humid temperate zone in areas with subtropical climates' (Toledo and Ordóñez, 1993).

Tropical and subtropical vegetation covers less than 30% of Mexico (Neyra and Durand, 1998). Tropical rainforest is present only in southern Mexico, mainly in Chiapas. This forest is very humid, with fungi fruiting throughout the year. The majority of these fungi are lignicolous, and few are humicolous. High temperatures and humidity favour rapid decomposition of the humus, so the substratum of humicolous fungi is available for only short periods of time (Guzmán-Dávalos and Guzmán, 1979). In contrast, the subdeciduous and deciduous tropical forests are dry in winter and spring and not as rich in fungi. They have sufficient humidity to support fungal fruiting during only a few summer months.

The mesophytic forest is a type of subtropical humid vegetation. It is also called cloud forest owing to the high relative humidity, which creates a mist for most of the year. This condition promotes the existence of a very rich mycobiota, which has been well studied in Mexico relative to other tropical vegetation types. According to Guzmán (1996), the mesophytic forest has many similarities with the deciduous forests of eastern USA, and they have many fungi in common. In Mexico, the mesophytic forest covers only 0.07% of the land surface and it is considered to be one of the most threatened ecosystems (Flores-Villela and Gerez, 1994).

Mycological Studies on Dark-spored Agarics

Studies of Mexican agarics began with Murrill in 1910, although there are some isolated records from the 18th century (Guzmán-Dávalos, 2000). Murrill described many dark-spored agarics from tropical regions of Mexico, including 63 agarics of which 25 were dark-spored and belonged to the genera: *Agaricus*, *Agrocybe*, *Bolbitius*, *Coprinus*, *Cortinarius*, *Galerina*, *Inocybe*, *Melanotus*, *Phaeomarasmius*, *Pholiota*, *Psathyrella* and *Simocybe* (Halling, 1986). The start of modern investigations of Mexican agarics was directly related to the rediscovery of hallucinogenic mushrooms in the 1950s, with the works of Wasson and Heim (e.g. Heim, 1956; Heim and Wasson, 1958) followed by Singer

(1957, 1958a,b,c; Singer and Smith, 1958a,b). Singer's first visit to Mexico was motivated by the curiosity surrounding these mushrooms. From there, his interest developed into a study of Mexican agarics, and he played an outstanding role in the study and understanding of Mexican *Agaricales*, especially of those from the tropics, and was a great influence in Mexican mycology. His authority was so great that Guzmán (1994) considered that fungal taxonomy in Mexico could be historically divided between pre- and post-Singer. Also during the 1950s, Guzmán initiated his research with Mexican mushrooms, specifically with *Psilocybe* (Guzmán, 1958, 1959), under the great influence of Singer. Guzmán has worked with this genus ever since and it is no coincidence that *Psilocybe* is now the most studied fungal genus in Mexico.

Most of the Mexican fungal inventories include few species of dark-spored agarics, although there are some exceptions. Guzmán and Johnson (1974) considered 32 species of basidiomycetes collected in a tropical zone in Chiapas, of which 11 were dark-spored agarics. Welden and Guzmán (1978) and Welden *et al.* (1979) listed more than 400 species, including about 50 dark-spored agarics of temperate, subtropical and tropical vegetation of south-western Mexico. In the same region, Guzmán-Dávalos and Guzmán (1979) found 170 species, including 21 dark-spored agarics, but only ten of them were from tropical regions. Guzmán (1983b) reported 274 species from the Yucatan Peninsula, of which 25 were dark-spored tropical agarics, and of these eight were *Psathyrella* species. Frutis and Guzmán (1983) made an inventory of the macroscopic fungi of Hidalgo State recording 422 species including 62 with dark spores. This did not include tropical localities, only mesophytic forest with 24 species of dark-spored agarics, mainly of *Psilocybe* and *Inocybe*. Guzmán and Guzmán-Dávalos (1984) recorded four dark-spored agarics among 35 species found in Veracruz State. From a list of 270 species of higher fungi from Michoacán State, 26 were dark-spored agaric taxa but only eight were from subtropical (mainly mesophytic forest) or tropical regions (Díaz-Barriga *et al.*, 1988).

The genera of dark-spored agarics that have currently received most attention in Mexico are *Agaricus*, *Coprinus*, *Cortinarius* (only subgenus *Dermocybe*), *Gymnopilus*, *Hypholoma*, *Inocybe*, *Micropsalliota*, *Panaeolus*, *Phaeocollybia*, *Psathyrella* and *Psilocybe*. Recently, *Crepidotus* has also been studied, for example, Bandala *et al.* (1999) studied two species of Mexican *Crepidotus*, one from temperate and mesophytic forests and the other from tropical rainforest. However, if only the tropical genera, or those with tropical representatives, had been considered, we would have a very limited impression of the tropical dark-spored Mexican agarics.

The genus *Agaricus* was studied by Gutiérrez-Ruiz and Cifuentes (1990). They considered 14 species from the subgenus *Agaricus*, from mesophytic forest and *Pinus–Quercus* forest. *Coprinus* is poorly known in Mexico, with very few descriptions in the literature (e.g. Pérez-Silva, 1976). There is only one publication concerning *Cortinarius* subgenus *Dermocybe*, and the six species considered are from temperate forests (Sánchez Macías *et al.*, 1987). *Hypholoma* has

been studied by Guzmán as part of his research on genera related to *Psilocybe* (Guzmán, 1975, 1999), and six species are known from the country. *Inocybe* was studied by Pérez-Silva (1967, 1976–1982) who recorded about 60 species for Mexico, mainly from temperate regions. An unusual tropical species was described by Guzmán (1982), *Inocybe tropicalis* Guzmán, from Yucatan.

Micropsalliota, a tropical and subtropical genus mainly from Asia, has been studied by Heinemann. In Mexico, three species are known, two of them endemic and from a mesophytic forest (Guzmán-Dávalos, 1992; Guzmán-Dávalos and Heinemann, 1994). There are certainly more species waiting to be described in collections already made from tropical forests by the present author and collaborators. In Guzmán and Pérez-Patraca's monograph (1972) of the Mexican species of *Panaeolus s. l.*, 11 taxa, 9 of them from tropical regions, were considered. Among them, *Panaeolus antillarum* (Fr.) Dennis and *Copelandia cyanescens* (Berk. & Broome) Singer are the most common in the country.

Mexican species of *Phaeocollybia* have been studied extensively by Bandala and collaborators. To date 19 species are known, mainly from temperate forests, although some are from mesophytic forests (Guzmán *et al.*, 1987; Bandala *et al.*, 1989, 1996; Bandala and Montoya, 1994). Nineteen is high compared with the 45 species known throughout the world, according to Hawksworth *et al.* (1995). Tropical species of *Psathyrella* in Mexico have been studied by Guzmán and Johnson (1974), Guzmán (1983b) and Guzmán *et al.* (1988). For example, *Psathyrella smithii* Guzmán was described from a tropical rainforest in Chiapas and *Psathyrella asperospora* (Cleland) Guzmán, Bandala & Montoya (= *Lacrymaria asperospora* (Cleland)Watling, = *Psathyrella sepulchralis* Singer, Smith & Guzmán) is common in disturbed areas of the cloud forest.

As mentioned above, *Psilocybe* is the most studied genus in Mexico, not only among the dark-spored agarics but also of all the agarics. In his monograph of *Psilocybe* and the supplement published in 1995, Guzmán (1983a, 1995) accepted 172 taxa of which 40 are known from Mexico. A very common species in tropical and subtropical regions is *Psilocybe cubensis* (Earle) Singer, and because of its size, abundance and ease of cultivation it is the most commonly used hallucinogenic mushroom, albeit illegally. *Psilocybe uxpanapensis* Guzmán is one of the few hallucinogenic fungi that grows only in tropical rainforests, but it is in danger of extinction because of rapid deforestation. New tropical species remain to be described. Only recently Guzmán described two species from a mesophytic forest in Jalisco (Guzmán, 1998) and three from Veracruz, two from mesophytic forest and one from alpine forest at 3300 m (Guzmán *et al.*, 1999).

The Genus *Gymnopilus*

This genus belongs to *Cortinariaceae*, *Cortinarieae* (Singer, 1986). It is distinguished macroscopically by the yellow to ferruginous basidiomata and lamellae. Microscopically, the spores are ellipsoid, or sometimes widely ellipsoid,

verrucose and ferruginous. The cystidia are an important taxonomic feature; in many species they are lageniform, capitate or subcapitate. An important ecological feature of the genus is its lignicolous habitat. *Gymnopilus* can grow on wood in different states of decay, including very decayed wood. The only monograph on the genus is that of Hesler (1969), in which only one species from Mexico was considered.

Currently, 31 species of the genus are known in Mexico, among 175 known in the world (Hawksworth *et al.*, 1995). It is interesting to note that of the 31 species, 17 species are unique to Mexico. Six are found only in the USA and Mexico. Four, among them *Gymnopilus penetrans* (Fr.: Fr.) Murrill and *Gymnopilus sapineus* (Fr.) R. Maire, have a worldwide distribution. Two, *Gymnopilus robustus* and *Gymnopilus rugulosus*, grow in Mexico and Central America. *Gymnopilus palmicola* is in Mexico, USA and Cuba, and *Gymnopilus lateritius* in Mexico and the Lesser Antilles (Guzmán-Dávalos, 1993; Guzmán-Dávalos and Guzmán, 1995; Guzmán-Dávalos and Ovrebo, 2001) (Fig. 5.1).

Of the 31 species known in Mexico, 58% are from temperate forests consisting chiefly of *Quercus* and *Pinus*; 42% from the warm regions: comprising seven species from the tropics, two from mesophytic forest and four that can be found in both tropical and temperate regions with some tropical influence (Fig. 5.2). These numbers reflect the status of *Gymnopilus* in the tropics, a genus which used to be cited mainly from temperate regions (Hesler, 1969; Høiland, 1990). Until recently, Mexican mycological expeditions concentrated on temperate and subtropical forests, leaving the tropical regions without due attention. The number of tropical species is likely to increase as these regions are better explored. This is also happening in other tropical regions, for example, Høiland (1998) recently described two new species from Africa.

The tropical, subtropical and temperate species are shown in Table 5.1. One of the largest basidioma of the genus is produced by *G. robustus*, described from Mexico and recently collected in Central America (Costa Rica and Panama) (Guzmán-Dávalos, 1994; Guzmán-Dávalos and Ovrebo, 2000). It fruits only on

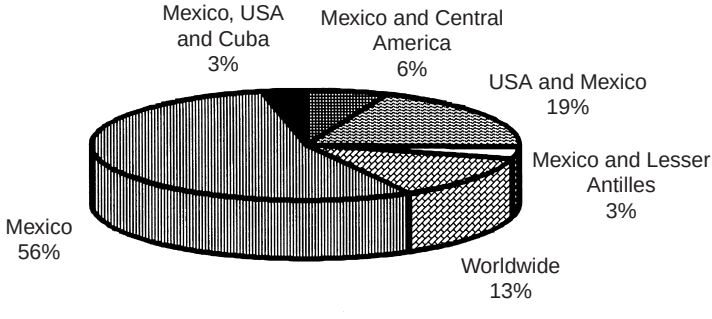

Fig. 5.1. World distribution of the Mexican species of *Gymnopilus*.

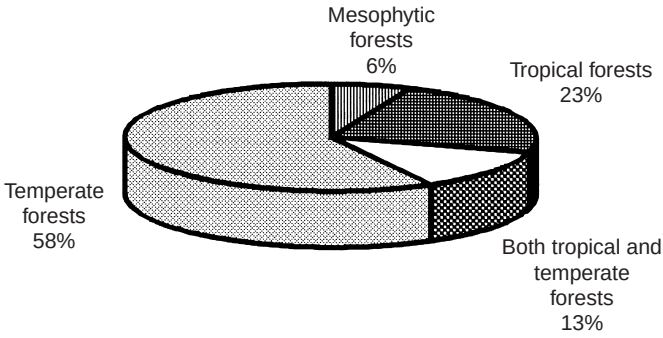

Fig. 5.2. Mexican species of *Gymnopilus* according to vegetation type.

stems or adventitious root masses of palms in tropical regions, but may have an even wider Neotropical distribution. *G. robustus* is easy to identify microscopically because the spores are widely ellipsoid to subglobose and have a conspicuous perisporium. *Gymnopilus tuxtlense* is known only from tropical regions of Mexico (Guzmán-Dávalos, 1994). It is easy to recognize owing to its small and slender basidiomata, papillate pileus and a yellow pubescent stipe base. Another producer of large basidiomata is *G. rugulosus*. It was described from Mexico (Valenzuela *et al.*, 1981), and recently was recorded in Costa Rica (Guzmán-Dávalos and Ovrebo, 2000). In both countries it is abundant in subtropical forests. Owing to its tuberculate, widely ellipsoid to subglobose spores, *G. rugulosus* is also very easy to identify under the microscope. *Gymnopilus lepidotus* is known from subtropical and tropical rainforest of Florida, USA and Mexico (Hesler, 1969; Guzmán-Dávalos, 1996). It has small basidiomata with tiny erect purplish squamules. *G. palmicola* was described from Cuba (Murrill, 1913). The only colour photograph in Singer's book (Singer, 1986), as *Gymnopilus aculeatus* (Bres. & Roumg.) Singer, is of this species. The specimen in the photograph was found in a greenhouse in the USA, growing in a living orchid collected from Oaxaca in Mexico. It is also known from Florida, USA (Guzmán-Dávalos and Guzmán, 1995). *Gymnopilus subpurpuratus* is known both from *Pinus* and cloud forests only in Mexico. It is probably a hallucinogenic species since its basidiomata stain blue-green when bruised (Guzmán-Dávalos and Guzmán, 1991).

The destruction of habitats, especially tropical ones, is alarming. We need to place special emphasis on the study of tropical regions, otherwise it will be too late. We know that there are still many tropical species of *Gymnopilus* waiting to be named, some of them already collected but not yet studied and many others not even collected. It is almost certain that tropical species common in other countries, such as *Gymnopilus chrysopellus* (Berk. & M. A. Curtis) Murrill (Hesler, 1969; Kreisel, 1971) or *Gymnopilus dilepis* (Berk. & Broome) Singer (Pegler, 1986) will be present in Mexico. Also there are many other dark-spored agarics not described from the Mexican tropics. If in well-studied genera, such

Table 5.1. Tropical species of *Gymnopilus* from Mexico, according to vegetation type.

Tropical forests (evergreen, deciduous and subdeciduous)
G. hemipenetrans Guzmán-Dávalos
G. lateritius (Pat.) Murrill
G. medius Guzmán-Dávalos
G. robustus Guzmán-Dávalos
G. cf. *subdryophilus* Murrill
G. subearlei Valenz., Guzmán & J. Castillo
G. tuxtlense Guzmán-Dávalos
Subtropical forests (mesophytic)
G. rugulosus Valenz., Guzmán & J. Castillo
G. subgeminellus Guzmán-Dávalos & Guzmán
Tropical, subtropical and temperate forests (in many cases the temperate forests have tropical influence)
G. fulvosquamulosus Hesler
G. lepidotus Hesler
G. palmicola Murrill
G. subpurpuratus Guzmán-Dávalos & Guzmán

as *Psilocybe*, there are still many unnamed species, what finds can be expected in genera not yet studied? Genera such as *Conocybe*, *Cystoagaricus*, *Melanotus*, *Phaeomarasmius*, *Pyrrhoglossum*, among others, need to be addressed.

Acknowledgements

My thanks to Roy Watling and Tony Whalley of the British Mycological Society Millennium Meeting for inviting me to address the symposium. Financial support was provided by the British Mycological Society, CONABIO (National Commission for the Study and Use of Biodiversity of Mexico), Idea Wild, SIMORELOS-CONACyT (National Council of Science and Technology of Mexico) and University of Guadalajara. I thank also Gastón Guzmán for his critical review of the paper. Pablo Munguía kindly helped with the English translation, and the editors of the Tropical Mycology volumes contributed in making the English more concise.

References

Bandala, V.M. and Montoya, L. (1994) Further investigations on *Phaeocollybia* with notes on infrageneric classification. *Mycotaxon* 52, 397–422.

Bandala, V.M., Guzmán, G. and Montoya, L. (1989) Additions to the knowledge of *Phaeocollybia* (*Agaricales*, *Cortinariaceae*) in Mexico with description of new species. *Mycotaxon* 35, 127–152.

Bandala, V.M., Montoya, L., Guzmán, G. and Horak, E. (1996) Four new species of *Phaeocollybia*. *Mycological Research* 100, 239–243.

Bandala, V.M., Montoya, L. and Moreno, G. (1999) Two *Crepidotus* from Mexico with notes on selected type collections. *Mycotaxon* 72, 403–416.

Díaz-Barriga, H., Guevara-Fefer, F. and Valenzuela, R. (1988) Contribución al conocimiento de los macromicetos del Estado de Michoacán. *Acta Botánica Mexicana* 2, 21–44.

Flores-Villela, O. and Gerez, P. (1994) *Biodiversidad y conservación en México: vertebrados, vegetación y uso de suelo*. CONABIO and UNAM, Mexico, DF, Mexico.

Frutis, I. and Guzmán, G. (1983) Contribución al conocimiento de los hongos del Estado de Hidalgo. *Boletín de la Sociedad Mexicana de Micología* 18, 219–265.

Gutiérrez-Ruiz, J. and Cifuentes, J. (1990) Contribución al conocimiento del género *Agaricus* subgénero *Agaricus* en México, I. *Revista Mexicana de Micología* 6, 151–177.

Guzmán, G. (1958) El hábitat de *Psilocybe muliercula* Singer & Smith (= *Ps. wassonii* Heim), agaricáceo alucinógeno mexicano. *Revista de la Sociedad Mexicana de Historia Natural* 19, 215–229.

Guzmán, G. (1959) Sinopsis de los conocimientos sobre los hongos alucinógenos mexicanos. *Boletín de la Sociedad Botánica de México* 24, 14–34.

Guzmán, G. (1975) New and interesting species of *Agaricales* of Mexico. In: Bigelow, H. and Thiers, H. (eds) *Studies on Higher Fungi. Beihefte zur Nova Hedwigia* 51. Cramer, Vaduz, Lichtenstein, pp. 99–118.

Guzmán, G. (1982) New species of fungi from the Yucatan Peninsula. *Mycotaxon* 16, 249–261.

Guzmán, G. (1983a) The genus *Psilocybe. Beihefte zur Nova Hedwigia* 74. Cramer, Vaduz, Lichtenstein.

Guzmán, G. (1983b) Los hongos de la Península de Yucatán. II. Nuevas exploraciones y adiciones micológicas. *Biotica* 8, 71–100.

Guzmán, G. (1990) La micología en México. *Revista Mexicana de Micología* 6, 11–28.

Guzmán, G. (1994) *In memoriam* Dr. Rolf Singer 1907–1994. *Revista Mexicana de Micología* 10, 199–201.

Guzmán, G. (1995) Supplement to the monograph of the genus *Psilocybe*. In: Petrini, O. and Horak, E. (eds) *Taxonomic monographs of Agaricales. Bibliotheca Mycologica* 159. Cramer, Berlin, pp. 91–141.

Guzmán, G. (1996) Observations on some fungi from Louisiana and Mississippi in comparison with those of Mexico. *Tulane Studies in Zoology and Botany* 30, 69–74.

Guzmán, G. (1998) Las especies de *Psilocybe* (*Fungi, Basidiomycotina, Agaricales*) conocidas de Jalisco (México) y descripción de dos nuevas para la ciencia. *Acta Botánica Mexicana* 43, 23–32.

Guzmán, G. (1999) New combinations in *Hypholoma* and information on the distribution and properties of the species. *Documents Mycologiques* 29(114), 65–66.

Guzmán, G. and Guzmán-Dávalos, L. (1984) Nuevos registros de hongos en el Estado de Veracruz. *Boletín de la Sociedad Mexicana de Micología* 19, 221–244.

Guzmán, G. and Johnson, P.D. (1974) Registros y especies nuevas de los hongos de Palenque, Chiapas. *Boletín de la Sociedad Mexicana de Micología* 8, 73–105.

Guzmán, G. and Pérez-Patraca, A.M. (1972) Las especies conocidas del género *Panaeolus* en México. *Boletín de la Sociedad Mexicana de Micología* 6, 17–53.

Guzmán, G., Bandala, V.M. and Montoya, L. (1987) The known species of *Phaeocollybia* (*Agaricales, Cortinariaceae*) in Mexico. *Mycotaxon* 30, 221–238.

Guzmán, G., Montoya-Bello, L. and Bandala-Muñoz, V.M. (1988) A new species of *Psathyrella* (*Agaricales*, *Coprinaceae*) from Mexico with discussions on the known species. *Brittonia* 40, 229–234.

Guzmán, G., Ramírez-Guillén, F., Tapia, F. and Navarro, P. (1999) Las especies del género *Psilocybe* (*Fungi*, *Basidiomycotina*, *Agaricales*) conocidas de Veracruz (México). *Acta Botánica Mexicana* 49, 35–46.

Guzmán-Dávalos, L. (1992) First record of the genus *Micropsalliota* (*Agaricaceae*, *Agaricales*) in Mexico. *Mycotaxon* 43, 199–205.

Guzmán-Dávalos, L. (1993) Contribución al conocimiento del género *Gymnopilus* (*Agaricales*, *Cortinariaceae*) en México. MSc thesis, Facultad de Ciencias, UNAM, Mexico, DF, Mexico.

Guzmán-Dávalos, L. (1994) New species of *Gymnopilus* (*Agaricales*, *Cortinariaceae*) from Mexico. *Mycotaxon* 50, 333–348.

Guzmán-Dávalos, L. (1996) New records of the genus *Gymnopilus* (*Agaricales*, *Cortinariaceae*) from Mexico. *Mycotaxon* 59, 61–78.

Guzmán-Dávalos, L. (2000) Los estudios sobre Agaricales en México. *Boletín IBUG (Instituto de Botánica, Universidad de Guadalajara*) 6, 279–295.

Guzmán-Dávalos, L. and Guzmán, G. (1979) Estudio ecológico comparativo entre los hongos (macromicetos) de los bosques tropicales y los de coníferas del Sureste de México. *Boletín de la Sociedad Mexicana de Micología* 13, 89–125.

Guzmán-Dávalos, L. and Guzmán, G. (1991) Additions to the genus *Gymnopilus* (*Agaricales*, *Cortinariaceae*) from Mexico. *Mycotaxon* 41, 43–56.

Guzmán-Dávalos, L. and Guzmán, G. (1995) Toward a monograph of the genus *Gymnopilus* (*Cortinariaceae*) in Mexico. *Documents Mycologiques* 25(98–100), 197–212.

Guzmán-Dávalos, L. and Heinemann, P. (1994) *Micropsalliota subalpina* nov. sp. (*Agaricaceae*) from Mexico. *Bulletin Jardin Botanique National de Belgique* 63, 195–199.

Guzmán-Dávalos, L. and Ovrebo, C. (2001) Some species of *Gymnopilus* from Costa Rica and Panama. *Mycologia* 93, 398–404.

Halling, R.E. (1986) An annotated index to species and infraspecific taxa of Agaricales and Boletales described by William A. Murrill. *Memoirs of the New York Botanical Garden* 40, 1–120.

Hawksworth, D.L., Kirk, P.M., Sutton, B.C. and Pegler, D.N. (1995) *Ainsworth & Bisby's Dictionary of the Fungi*, 8th edn. CAB International, Wallingford, UK.

Heim, R. (1956) Les champignons divinatoires utilisés dans les rites des indies mazatèques, recueillis au cours de leur premier voyage au Mexique, en 1953, par Mme. Valentina Pavlovna Wasson et M.R. Gordon Wasson. *Comptes Rendus des Séances de l'Académie des Séances* 242, 965–968.

Heim, R. and Wasson, R.G. (1958) *Les champignons hallucinogènes du Mexique*. Archives du Muséum National d'Histoire Naturelle 6, 1–324.

Hesler, L.R. (1969) *North American Species of Gymnopilus. Mycological Memoirs* 3. Hafner, New York.

Høiland, K. (1990) The genus *Gymnopilus* in Norway. *Mycotaxon* 39, 257–279.

Høiland, K. (1998) *Gymnopilus purpureosquamulosus* and *G. ochraceus* spp. nov. (*Agaricales*, *Basidiomycota*) – two new species from Zimbabwe. *Mycotaxon* 69, 81–85.

Kreisel, H. (1971) *Clave para la identificación de los macromicetos de Cuba*, 4. Ciencias Biológicas No. 16, Centro de Información Científica y Técnica, Universidad de La Habana, La Habana, Cuba.

Mittermeier, R.A. (1988) Primate diversity and the tropical forest: case studies from Brazil and Madagascar and the importance of the megadiversity countries. In: Wilson, E. (ed.) *Biodiversity*. National Academic Press, Washington, DC, pp. 145–154.

Murrill, W.A. (1910) Agaricales, *Boletaceae, Agaricaceae* (pars) and *Cantharelleae, Lactarieae* (pars). In: *North American Flora* 9 (3). New York Botanical Garden, New York, pp. 133–200.

Murrill, W.A. (1913) The *Agaricaceae* of tropical North America, VI. *Mycologia* 5, 18–36.

Neyra, L. and Durand, L. (1998) Biodiversidad. In: CONABIO. *La diversidad biológica de México: estudio de país, 1998*. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, Mexico, DF, Mexico, pp. 61–102.

Nishida, F.H. (1989) Review of mycological studies in the Neotropics. In: Campbell, D. and Hammond, D.H. (eds) *Floristic Inventory of Tropical Countries*. New York Botanical Garden, New York, pp. 494–533.

Pegler, D.N. (1986) *Agaric Flora of Sri Lanka*. Kew Bulletin Additional Series XII. HMSO, London.

Pérez-Silva, E. (1967) Les Inocybes du Mexique. *Anales del Instituto de Biología, Universidad Nacional Autónoma de México* 38, ser. Bot., 1–60.

Pérez-Silva, E. (1976) Hongos fimícolas de México, III. Especies poco conocidas del género *Coprinus* (*Agaricales*). *Boletín de la Sociedad Mexicana de Micología* 10, 23–26.

Pérez-Silva, E. (1976–1982) Nuevos registros en México para algunas especies del género *Inocybe* (Agaricales). *Anales del Instituto de Biología, Universidad Nacional Autónoma de México* 47–53, ser. Bot., 177–188.

Rzedowski, J. (1978) *Vegetación de México*. Editorial Limusa, Mexico, DF, Mexico.

Sánchez Macías, E., Pérez-Silva, E. and Pérez Amador, C. (1987) Consideraciones quimiotaxonómicas para el estudio de algunas especies del género *Dermocybe* (Cortinariaceae) en México. *Revista Mexicana de Micología* 3, 189–202.

Singer, R. (1957) Fungi mexicani, series prima – Agaricales. *Sydowia* 11, 354–374.

Singer, R. (1958a) Observations on agarics causing cerebral mycetism. *Mycopathologia et Mycologia Applicada* 9, 261–284.

Singer, R. (1958b) Mycological investigation on Teonanacatl, the Mexican hallucinogenic mushroom. Part I. The history of Teonanacatl, field work and culture work. *Mycologia* 50, 239–261.

Singer, R. (1958c) Fungi Mexicani, series secunda – Agaricales. *Sydowia* 12, 221–243.

Singer, R. (1986) *The Agaricales in Modern Taxonomy*. Koeltz, Koenigstein, Germany.

Singer, R. and Smith, A.H. (1958a) Mycological investigation on Teonanacatl, the Mexican hallucinogenic mushroom. Part II. A taxonomic monograph of *Psilocybe*, section *Caerulescentes*. *Mycologia* 50, 262–303.

Singer, R. and Smith, A.H. (1958b) New species of *Psilocybe*, Section *Caerulescentes*. *Mycologia* 50, 141–142.

Toledo, V.M. and Ordoñez, M.J. (1993) The biodiversity scenario of Mexico: a review of terrestrial habitats. In: Ramamoorthy, T.P., Bye, R., Lot, A. and Fa, J. (eds). *Biological Diversity of Mexico. Origins and Distribution*. Oxford University Press, New York, pp. 757–778.

Valenzuela, R., Guzmán, G. and Castillo, J. (1981) Descripciones de especies de macromicetos poco conocidas en Mexico, con discusiones sobre su ecología y distribución. *Boletín de la Sociedad Mexicana de Micología* 15, 67–120.

Welden, A. and Guzmán, G. (1978) Lista preliminar de los hongos, líquenes y mixomicetos de las regiones de Uxpanapa, Coatzacolacos, Los Tuxtlas, Papaloapan y Xalapa (parte de los estados de Veracruz y Oaxaca). *Boletín de la Sociedad Mexicana de Micología* 12, 59–102.

Welden, A.L., Dávalos, L. and Guzmán, G. (1979) Segunda lista de los hongos, líquenes y mixomicetos de las regiones de Uxpanapa, Coatzacolacos, Los Tuxtlas, Papaloapan y Xalapa (México). *Boletín de la Sociedad Mexicana de Micología* 13, 151-161.